Growth and survival of native tree species planted on an abandoned pasture in humid tropical lowland of Costa Rica

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Background

Deforestation and the increasing fragmentation have led to serious landscape degradation in Central America. Several reforestation projects were established since the 1990s opposing this trend.

Reforestation projects should recover diversity and ecosystem services faster than natural regeneration would do. Most projects use a limited number of fast growing species, resulting in a rapid recovery of biomass but a slow increase in diversity.

Is this the best strategy to provide ecosystem services and functions?

Ecosystem services are related to biodiversity and functional diversity. To test the performance of a large number of species and the effect of functional vs. species diversity we use a high diversity reforestation project in Costa Rica.

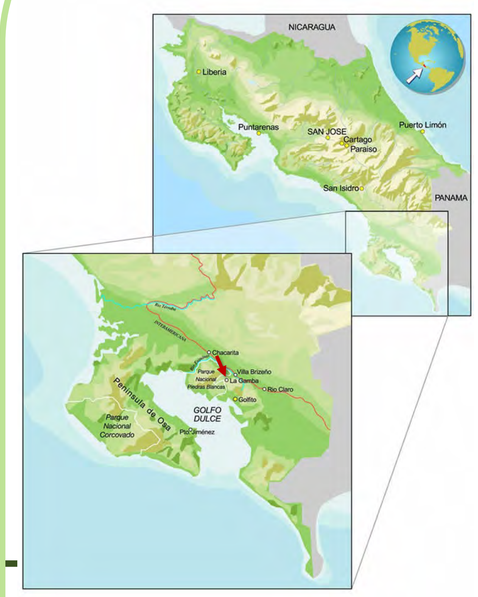

Figure 1: Study area (arrow) in the Golfo Dulce region of Costa Rica (adapted from Weissenhofer et al., 2008).

Study site

In 2013, more than 2.000 trees belonging to more than 100 native species were planted on an abandoned pasture close to La Gamba Biological Station in the humid tropical lowland of Costa Rica. To test the effect of functional diversity, tree species were assigned to three functional groups:

- high wood density (> 0.5 g/cm³),
- low wood density (< 0.5 g/cm³) and
- legumes.

These functional groups were planted in all seven possible combinations in replicated plots of 6 x 6 trees with the same number of species (9) per plot and a buffer of one tree row between plots (Fig. 2). Thereby functional diversity differed among plots but species diversity was uniform.

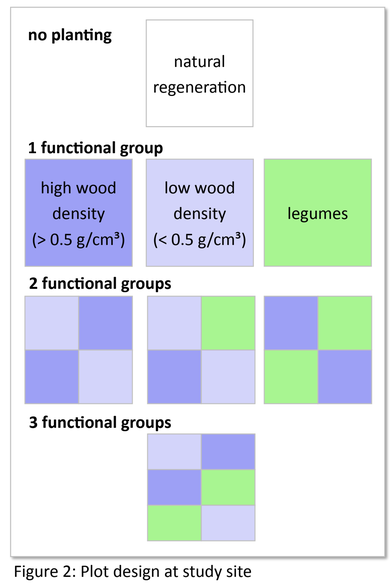

Figure 2: Plot design at study site

Recovery of pasture

Figure 3: Recovery of the study site during the first three years after planting

Questions

What are the effects of functional diversity on the recovery of ecosystem functions?

Which factors affect growth and survival of native tree species?

Methods

- Tree height, diameter and survival were measured in 2013, 2015 and 2016.
- Quality, shading and the effect of herbivory were semi-quantitative evaluated.
- Change in canopy cover was examined by calculating the LAI based on hemispherical photographs.

Results

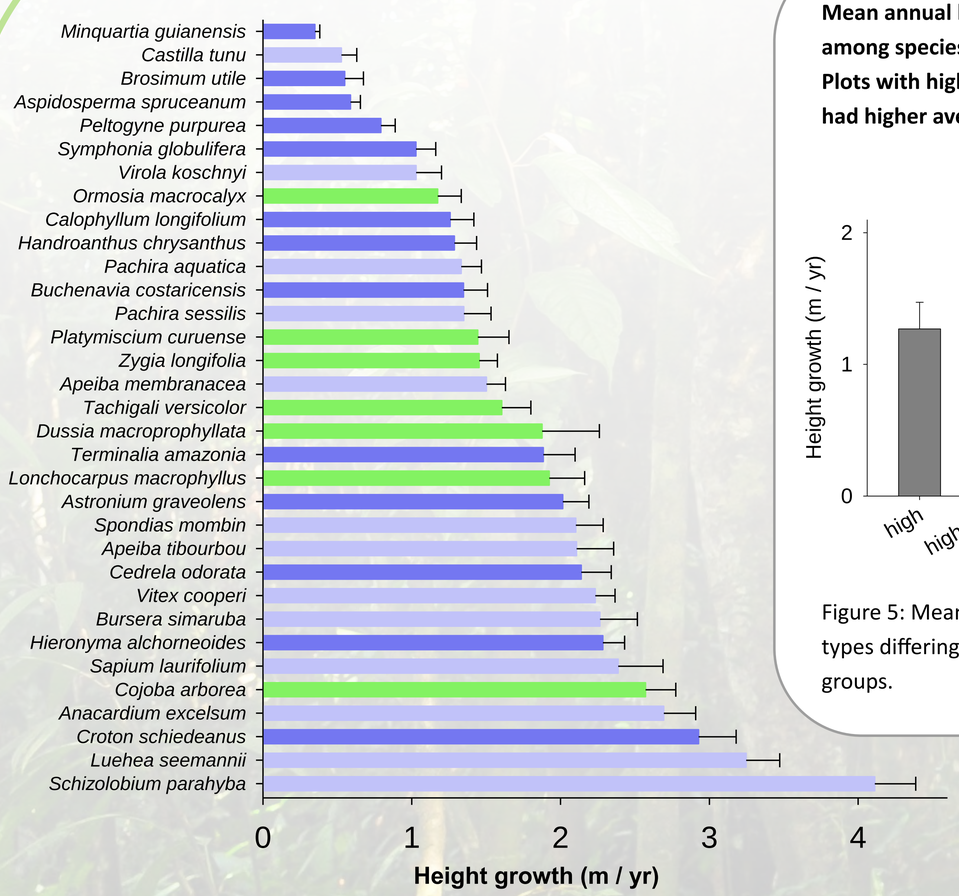

Figure 4: Height increment in m / yr (± SE) for the more abundant species.

Mean annual height increment differed among species (Fig. 4) and plot types. Plots with high functional diversity slightly had higher average growth rates (Fig. 5).

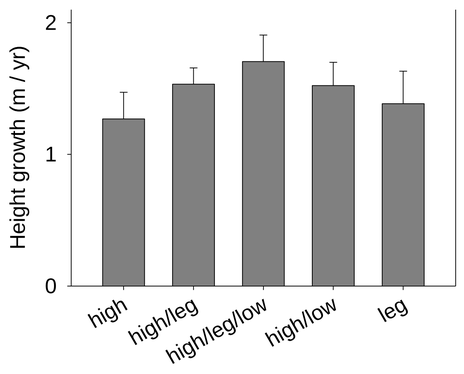

Figure 5: Mean height increment for plot types differing in combinations of functional groups.

We found a strong trade-off between growth and mortality of trees.

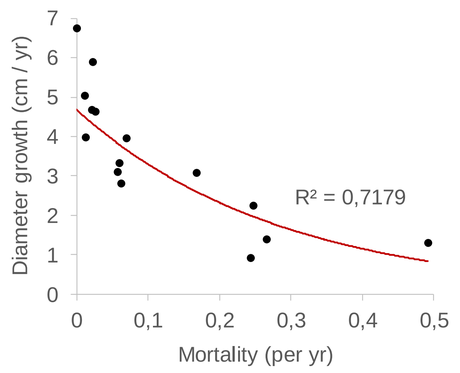

Figure 6: Mean mortality and diameter increment for species with > 50 observations.

Herbivory and mean annual height growth were positively correlated (Fig. 7), but there was no effect of neighboring trees based on the semi-qualitative estimate of shading.

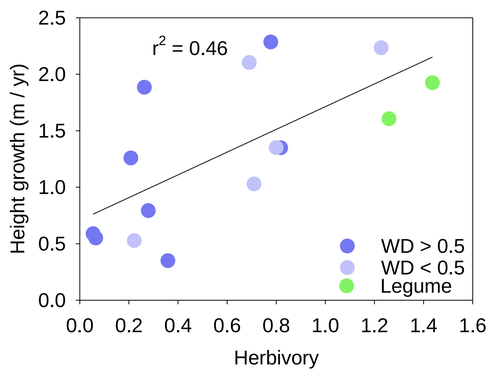

Figure 7: Relationship between herbivory (semi-quantitative) and height increment for the more abundant species.

The young forest grew fast. Two and three years after planting LAI had reached 1.3 and 2.2 respectively, with no significant differences between plot types.

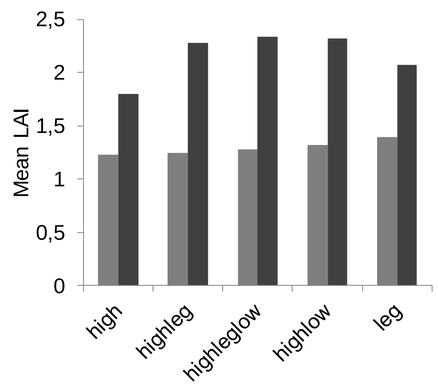

Figure 8: Mean LAI in 2015 and 2016 for the different plot types.

Conclusions & Outlook

Growth rates differed among tree species and plot type. While intensity of herbivory and height increment were correlated positively, shading and average LAI had no significant effects.
In case of the effects caused by the composition of functional groups, further measurements will track possible effects, which might be visible on the long-term.

Mortality was negatively correlated with diameter increment, which might not be remarkable compared to the results of other studies. As competition during initial growth phase is nearly eliminated through management, commonly discussed reasons for this relationship do not apply (e.g. shade tolerance, limitation in nutrients and water availability).
Further investigation therefore will be focused on mortality and its causing effects.

References

Weissenhofer, A. et al. (2008). " Natural and cultural history of the Golfo Dulce region, Costa Rica". Linz, Oberösterreich ,Oberösterr. Landesmuseen.